Institution:
University of Central Lancashire

Unit of Assessment:
12 - Engineering

Title of case study:
Making Tall Buildings Safe from Fire

Period when the underpinning research was undertaken:
2007-2019

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Richard Hull	Professor	Sept 2007 - Present
Anna Stec	Professor	Oct 2007 - Present

Period when the claimed impact occurred:
2018-2020

Is this case study continued from a case study submitted in 2014? Y/N
N

1. Summary of the impact (indicative maximum 100 words)

The Grenfell Tower fire sent shockwaves around the world. Occupants of high-rise buildings were too scared to sleep, while the social scandal raised significant questions for the government. The tragedy led to a desperate search to understand the causes, accompanied by urgent action to address them. Our work demonstrating the flammability of cladding products helped persuade the government to make residents of tall buildings safer by banning new installation of combustible facades and committing GBP3.5 billion for their replacement in existing towers. Replacement with non-combustible cladding has significantly reduced resident's anxiety, and led to dramatic shift towards the alternative mineral wool insulation in the UK.

2. Underpinning research (indicative maximum 500 words)

Until 2010 our research looked at the fire behaviour of materials and construction products, including polymers, flame retarded polymers, electric cables and thermal insulation. This followed the massive growth in the use of plastics by the construction industry over the last 50 years, which currently accounts for 20% of total European plastic consumption.

Related work on products for industrial buildings, such as warehouses, used test rooms built from composite or 'sandwich' panels, and showed the large differences in fire behaviour between combustible, such as polyisocyanurate (PIR), and non-combustible insulating fillings, such as mineral wool. This work showed that even buildings made from products with the highest fire safety certification could still make a very large contribution to fire growth, both by burning themselves, and when they did so, by driving a five-fold increase in the rate the contents burned [1].

After the Grenfell Tower fire, a detailed study of the fire behaviour of common façade products showed the dangers in terms of flammability and smoke toxicity of the types of combustible products that are used to clad tall buildings [2]. Soon after the fire, we obtained samples of the main products used to construct ventilated 'rainscreen' façades, like that on Grenfell Tower. This was in direct response to the absence of any available information on the composition or fire behaviour of the materials and products used to clad buildings. For example, we found that polythene (PE) filled aluminium composite panels (ACP) contained three times more fuel than the fire retarded versions (FR). The insulation products, PIR and phenolic foam, were flammable

although they were certified to have passed the regulatory tests. The results were reported to various Parliamentary and other regulatory groups as soon as they were obtained.

Following the Hackitt Review of Building Fire Safety Regulations, and in direct response to the Ministry of Housing, Communities and Local Government's (MHCLG) deliberation on the fire safety of façades, we worked with: the Fire Protection Association (FPA)/RISCAuthority, the insurance industry's fire experts; Arup Ltd, Fire Safety Engineers; and Ash and Lacey, one of the UK's largest cladding manufacturer's; to assess the fire behaviour and smoke toxicity using 5m facades in the BS8414 regulatory fire test. We used non-combustible ACP, with different types of insulation, installed using normal industry practice. The results showed that even the highest-rated ACP were incapable of resisting destruction by the fire, offering no protection to the underlying combustible insulation, which would then contribute to fire-spread up the side of the building [3]. The work was subsequently written up as two peer reviewed papers. The first, on the burning behaviour, showed why all façade products should be non-combustible, not just the outer panels. The second showed that the smoke flowing from the cavity of a burning façade would be toxic enough to incapacitate, and then kill, all the sheltering occupants [4, 5].

A critical appraisal of the regulatory regime which permitted combustible materials on the exterior faces of tall buildings (BS8414 and BR135) was undertaken, highlighting the inadequacies of the BS8414 test, and the BR135 criteria used to confer approval of combustible façade systems [6].

3. References to the research (indicative maximum of six references)

[1] Crewe, R.J., Hidalgo, J.P., Sørensen, M.X., McLaggan, M., Molyneux, S., Welch, S., Jomaas, G., Torero, J.L., Stec, A.A., and Hull, T.R., 'Fire performance of sandwich panels in a modified ISO 13784-1 small room test: the influence of increased fire load for different insulation materials,' (2018). *Fire Technology*, 54 (4). pp. 819-852. https://www.doi.org/10.1007/s10694-018-0703-5*.

[2] McKenna, S.T., Jones, N., Peck, G., Dickens, K., Pawelec, W., Oradei, S., Harris, S., Stec, A.A., Hull, T.R., 'Fire behaviour of modern façade materials – Understanding the Grenfell Tower fire,' (2019) *Journal of Hazardous Materials*, 368, pp. 115-123. https://doi.org/10.1016/j.jhazmat.2018.12.077*.

[3] RISCAuthority Interim Project Report. 'Occupant toxic exposure to fires in rain-screen cladding systems.' November 2018. https://www.thefpa.co.uk/news/news/news_detail.fpa-toxic-smoke-testing-results.html

[4] Jones, N., Peck, G., McKenna, S.T., Glockling, J.L.D., Harbottle, J., Stec, A.A., Hull, T.R. 'Burning behaviour of rainscreen façades,' (2021) *Journal of Hazardous Materials*, 403, 123894. https://www.doi.org/10.1016/j.jhazmat.2020.123894 (Available online from 9 September 2020)*.

[5] Peck, G., Jones, N., McKenna, S.T., Glockling, J.L.D., Harbottle, J., Stec, A.A., Hull, T.R., 'Smoke toxicity of rainscreen façades,' (2021) *Journal of Hazardous Materials*, 403, 123694, https://doi.org/10.1016/j.jhazmat.2020.123694 (Available on-line 14 August 2020)*.

[6] Schulz, J., Kent, D., Crimi, T., Glockling, J.L.D., Hull, T.R., 'A Critical Appraisal of the UK's Regulatory Regime for Combustible Façades' (2021) *Fire Technology*, 57, pp. 261-290. https://www.doi.org/10.1007/s10694-020-00993-z (Available on-line 27 May 2020)*.

* Indicates peer reviewed journal

4. Details of the impact (indicative maximum 750 words)

In the immediate aftermath of the Grenfell Tower fire, public opinion focused on the polyethylene-cored aluminium composite panels (ACP-PE) as a major cause of the tragedy. Hull appeared on broadcast media more than 20 times [A] explaining that the flammability of ACP-PE

and combustible insulation foam had combined with disastrous consequences. Shortly afterwards, the UK's Building Research Establishment (BRE) were instructed to undertake 7 tests using the BS8414 rig for the Department of Communities and Local Government (DCLG) on different combinations of ACP and insulation. The first two tests, using ACP-PE were stopped, before the insulation became involved in the fire, for safety reasons (as specified in BS8414), and the two tests with fire retarded ACP and combustible insulation were stopped after a little longer, again for safety reasons, so the contribution of the insulation remained unknown.

In September 2017, Hull and Stec were invited to present their findings, later reported in a peer-reviewed paper [2], showing the contribution of both insulation and polyethylene-filled ACP, to an All-Party Parliamentary Group, *The Parliamentary and Scientific Committee*. This was followed by a report in the Parliamentary Office of Science and Technology POSTNOTE [B], which brought our work to the wider attention of MPs and peers.

In February 2018, Stec was appointed to the Review of Building Regulations chaired by Dame Judith Hackitt as a member of Working Group 6 Products and Classification, and outlined our work, showing that changes to the building regulations were necessary. The Working Group concluded that revision was required of the test standard that allowed combustible materials to be used on tall buildings (BS 8414) [C].

In June 2018, Stec was also appointed as an Expert Witness to the Grenfell Tower Inquiry where she continues to investigate the effect of combustible materials on the tragedies that unfolded on the night of the fire. The progress of the Inquiry has been delayed due to the Covid-19 pandemic [D].

Hull and Stec have also independently reported their research to the All-Party Parliamentary Group, *Fire Safety Rescue,* to a separate audience of MPs and peers, and also to the Local Government Association, in person to its Chairman, Lord Porter of Spalding, and his team. The results were also presented to the Royal Institute of British Architects (RIBA) Expert Group on Fire Safety who presented their conclusions to the Parliamentary Select Committee on Communities, Housing and Local Government [E].

The work with the Fire Protection Association on combustible façades was reported directly to civil servants in the Ministry of Housing, Communities and Local Government (MHCLG), responsible for fire regulations in buildings, and published online before the announcement of the ban on combustible materials on tall residential buildings [F]. After our results had been reported to MHCLG, the Minister for Housing, the Rt Hon James Brokenshire, announced the ban on combustible products on all high-rise residential buildings. That ban came into force in December 2018. However, the problem of combustible facades on existing tall residential buildings is massive, and remediation will take time. The government has pledged GBP3,500,000,000 to remove combustible cladding from all the 12,000 residential buildings over 18 metres and to provide loans to support remediation in the 77,500 residential buildings between 11 and 18 metres. Overall, 839,000 people are believed to live in buildings over 11 metres with some form of cladding [G, H]. From January to May 2020, the MHCLG consulted on a proposal to increase the scope of the ban to cover all buildings over 11 metres, the outcome is still awaited (March 2021).

The fire hazard of another form of combustible cladding, High Pressure Laminate (HPL), which is cheaper, and approximately 3 times more prevalent than ACP-PE on high-rise buildings, was shown in our paper [2] to have a much higher heat release and shorter ignition time than ACP-

PE, and contributed to the 6 deaths in the Lakanal House fire in July 2009. In January 2019, Hull highlighted the risks of fires, similar to Grenfell, in HPL clad buildings [I]. In March 2019 the Government announced plans to undertake limited testing of the safest fire-retarded form of HPL, backed by non-combustible insulation, in the BS8414 large-scale scenario [J]. In January 2020, Hull's research helped inform a legal case by Leigh-Day Solicitors, who were preparing an action against the government for failing to protect the occupants of HPL clad buildings. As a result of increased awareness of the risks posed by HPL cladding from Hull's research, in May 2020 the Housing Secretary, Rt Hon Robert Jenrick, MP, announced that the government would release a further GBP1,000,000,000 to replace unsafe non-ACM cladding. This is predominantly combustible HPL cladding [K].

As a result of our research and the changing regulatory landscape there has been a decline in the use of combustible materials and an uptake in non-combustible alternatives on building exteriors. In a survey, the number of UK architects expecting PUR/PIR insulation usage to increase fell from 45% in 2016 to 17% in 2020, while over the same period, for glass wool insulation, usage expectation increased from 11% to 23%, and for stone wool insulation it increased from 21% to 37% [L, M]. Similar figures were reported for other European countries. In the UK the market share of non-combustible insulation has increased significantly, with a corresponding decrease in plastic foam. The Rockwool Group reported in their 2018 annual report that **"The focus on stronger fire-safety regulation affected the UK and Polish markets, contributing to greater demand for non-combustible stone wool building materials."** [N]

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] Examples of media appearances following Grenfell Tower fire including BBC Newsnight (13/07/17), Sky News (22/06/17), ITV News, Channel 4 News (20/07/17 and 28/07/17)

[B] POSTNOTE 575 May 2018 Fire Safety of Construction Products, The Parliamentary Office of Science and Technology, Westminster, London. www.parliament.uk/post

[C] Ministry of Housing, Communities and Local Government (2018) *Building a Safer Future Independent Review of Building Regulations and Fire Safety: Final Report,* p.93 URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707785/Building_a_Safer_Future_-_web.pdf [Accessed 25 February 2021]

[D] Grenfell Tower Inquiry – Expert Witnesses URL: https://www.grenfelltowerinquiry.org.uk/about/expert-witnesses [Accessed 2 March 2021]

[E] Housing, Communities and Local Government Committee, *Oral evidence: Independent review of building regulations and fire safety*, 27 June 2018, HC 555 Q233 http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/housing-communities-and-local-government-committee/independent-review-of-building-regulations/oral/86080.html [Accessed 25 February 2021]

[F] RISCAuthority Interim Project Report. Occupant exposure to fires in rain-screen cladding systems. November 2018.

[G] Building Safety Programme – Monthly Data Releases, Ministry of Housing, Communities and Local Government, London. https://www.gov.uk/government/publications/building-safety-programme-monthly-data-release-february-2019 [Accessed 25 February 2021]

[H] Local Government Association, Fire safety of cladding systems – supporting residents, https://www.local.gov.uk/sites/default/files/documents/10.53 Briefing - cladding scandal_01.pdf

[I] Inside Housing, January 2019, https://www.insidehousing.co.uk/news/next-grenfell-style-disaster-will-be-in-hpl-clad-tower-says-academic-59891 [Accessed 25 February 2021]

[J] Inside Housing April 2019, https://www.insidehousing.co.uk/news/government-seeks-contractor-for-new-large-scale-cladding-test-60830 [Accessed 25 February 2021]

[K] New £1 billion building safety fund to remove dangerous cladding from high rise buildings (2020) Ministry of Housing, Communities & Local Government https://www.gov.uk/government/news/new-1-billion-building-safety-fund-to-remove-dangerous-cladding-from-high-rise-buildings [Accessed 25 February 2021]

[L] European Architectural Barometer – Q2 2020 Material and Construction Trends, Arch Vision, USP, July 2020.

[M] Grenfell Tower; does this affect the future insulation choice in construction? (2018) USP Marketing Consultancy URL: https://www.usp-mc.nl/en/insights/grenfell-tower-does-this-affect-the-future-insulation-choice-in-construction-699/ [Accessed 25 February 2021]

[N] Rockwool Group Annual Report, 2018, relevant pages 9, 16, 18 & 19 https://p-cdn.rockwool.com/siteassets/investors/financial-reports/2018/rockwool_ar_2018_web_final_01_u052019.pdf?f=20201204090826&dl=1 [accessed 9 March 2021]